

The Nuclear Renaissance in a Global Context

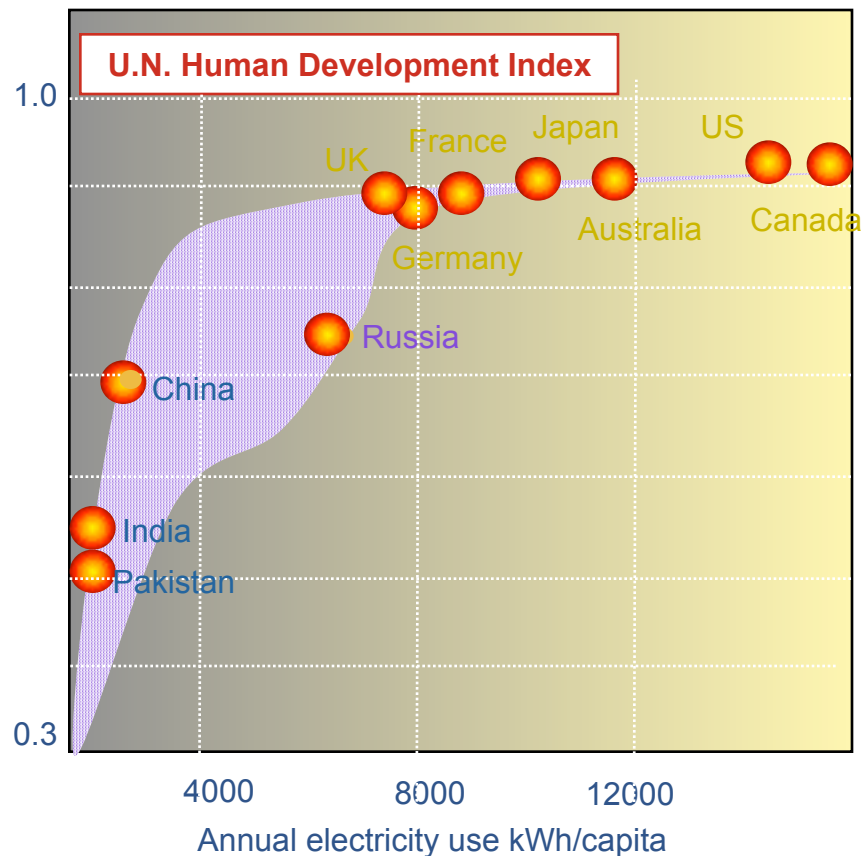


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Availability of energy is essential to achieving a high quality of life



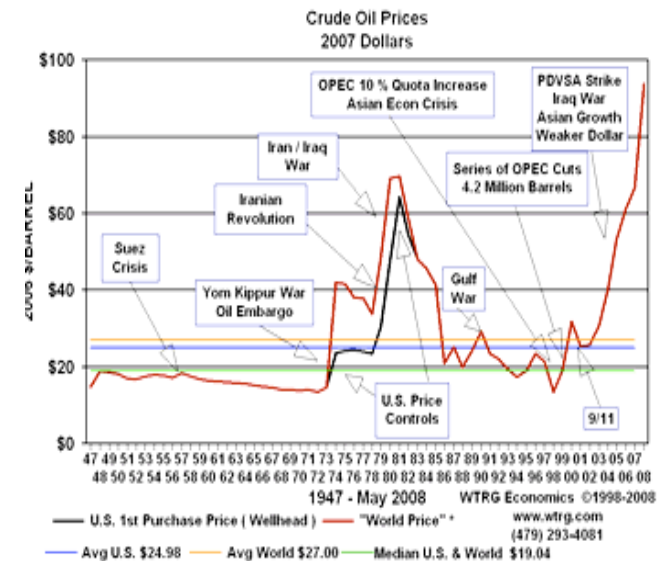
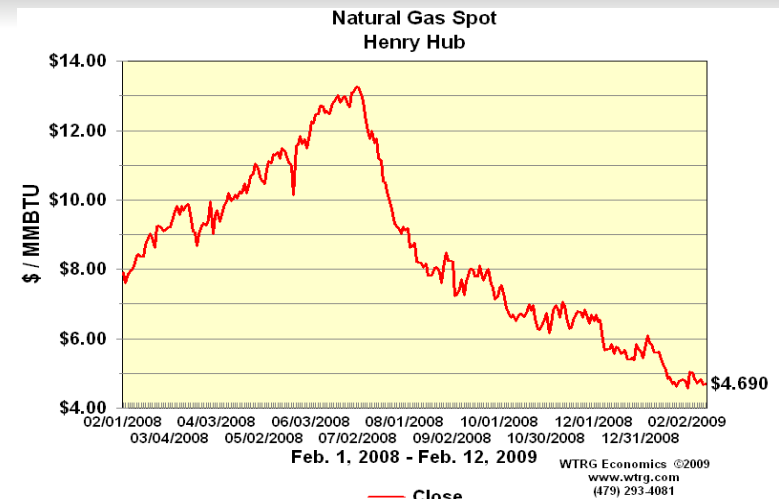
- Energy use will grow as developing countries achieve affluence.
- Affluence in developing countries will lead to more stable and peaceful world
- 10 billion people consuming energy at US levels will result in world energy demand increasing by 10 fold
- All forms of energy production have an environmental impact

A large increase in energy is necessary to fuel a more peaceful world



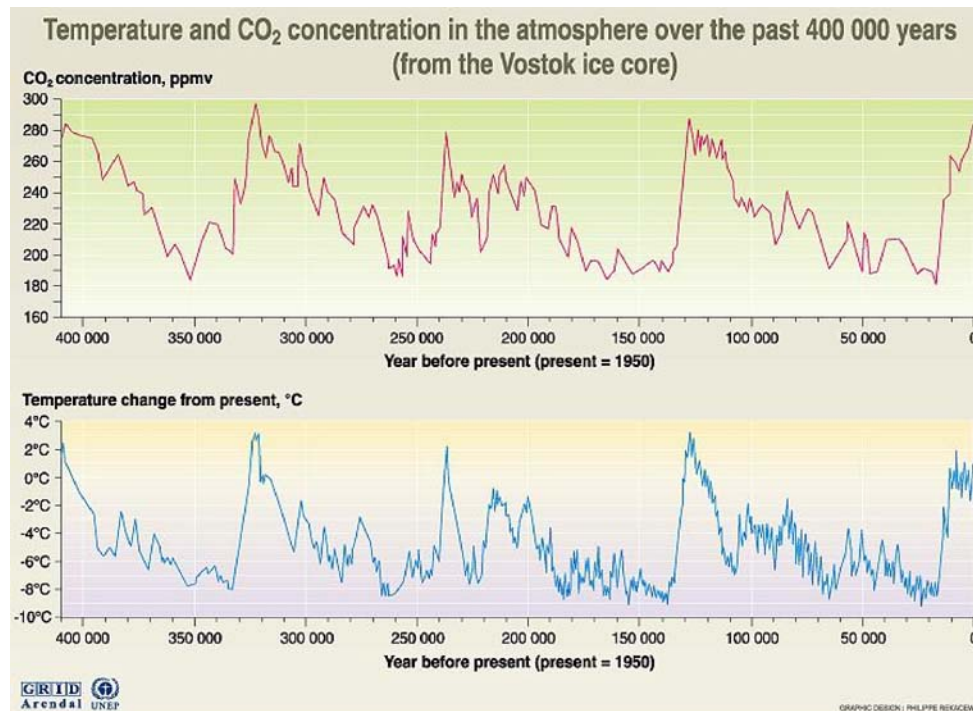
The Energy Challenge...

- Volatile prices for oil and natural gas
- Energy security
- Increased risk of climate change with burning of fossil fuels

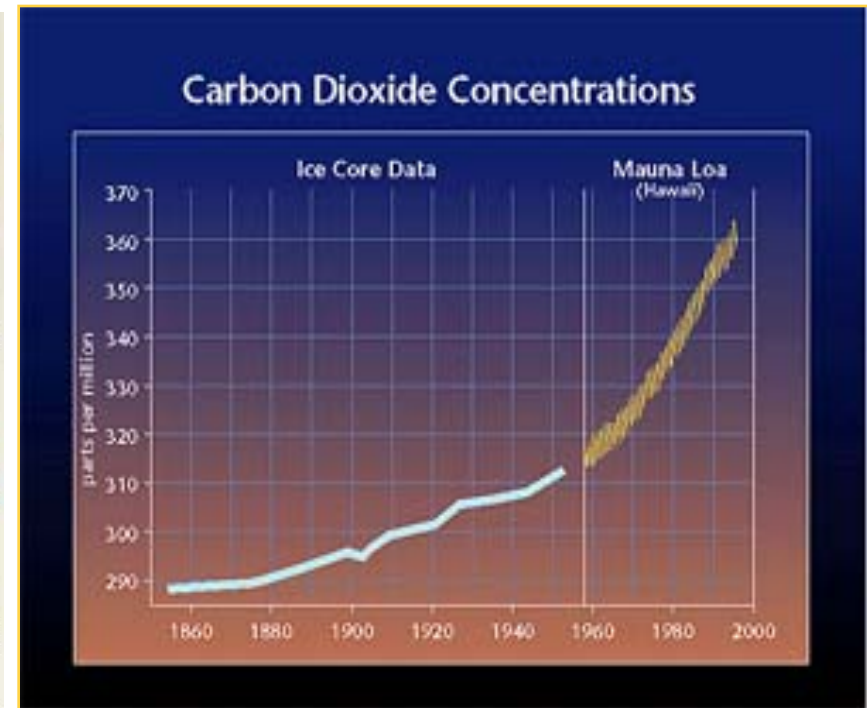




Attention on potential climate change is increasing



Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3June), pp 429-436, 1998.

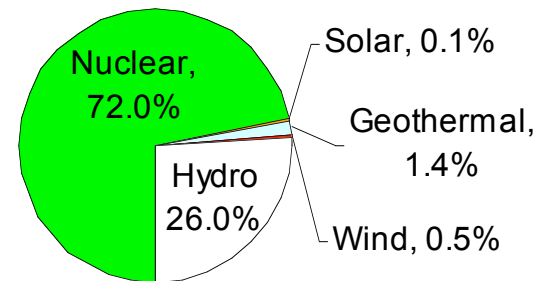
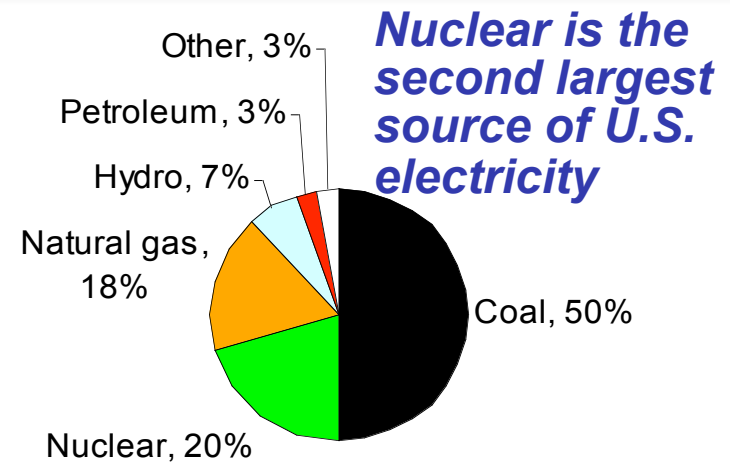


- Current CO₂ levels approaching 380 ppm are unprecedented
- Levels of CO₂ tolerance estimates are between 450–750 ppm
- We may be quickly approaching an environmental crisis



Nuclear Energy is on the Critical Path to a Sustainable Future

- **As energy needs rise, oil and gas prices increase, and pace of global warming increases, nations are looking to nuclear power**
 - Nuclear and hydroelectric are the only carbon-neutral base load electricity sources
 - Low fuel and production costs, competitive operating economics and performance
- **In the US, nuclear energy displaces carbon emissions equivalent to that emitted each year by automobiles**
- **U.S. preparing to build over 30 new plants in the next 15 years**
- **Beyond electricity, nuclear energy can be used to supplement or supplant fossil fuels**
 - High temperature process heat
 - Producing energy carriers such as hydrogen for petroleum upgrade



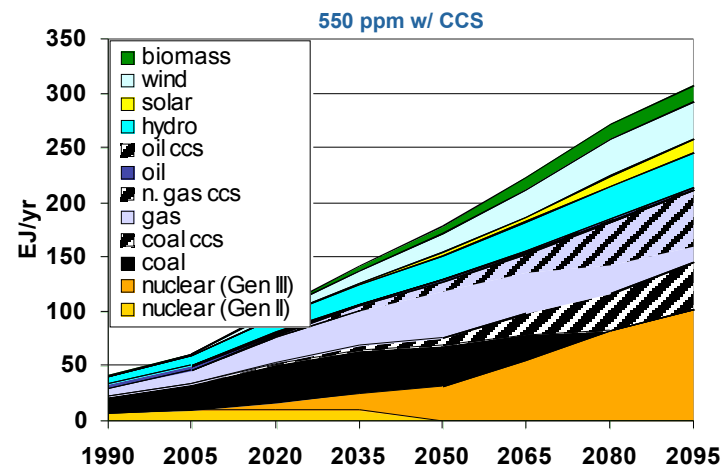
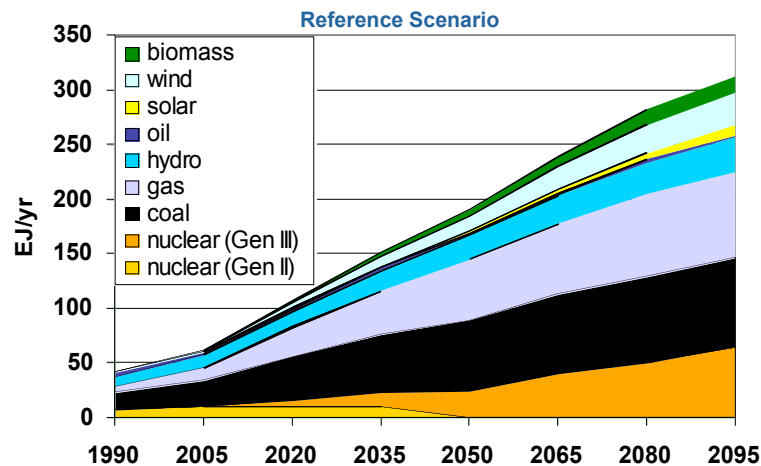
Nuclear energy is the dominant non-fossil electricity technology

In the U.S., 104 nuclear plants generate ~20% of our nation's electricity, and over 70% of our clean electricity



Global Demand for Nuclear Energy Will Increase

- **Global demand for all energy will grow**
 - Global electricity consumption will increase 5-fold by 2100
 - Nuclear power will expand global electricity market share by 25%
 - Nuclear growth will challenge uranium and waste disposal resources
- **Limiting CO₂ levels results in less fossil, more nuclear and renewables**
 - Carbon capture and sequestration technologies are key to fossil market shares

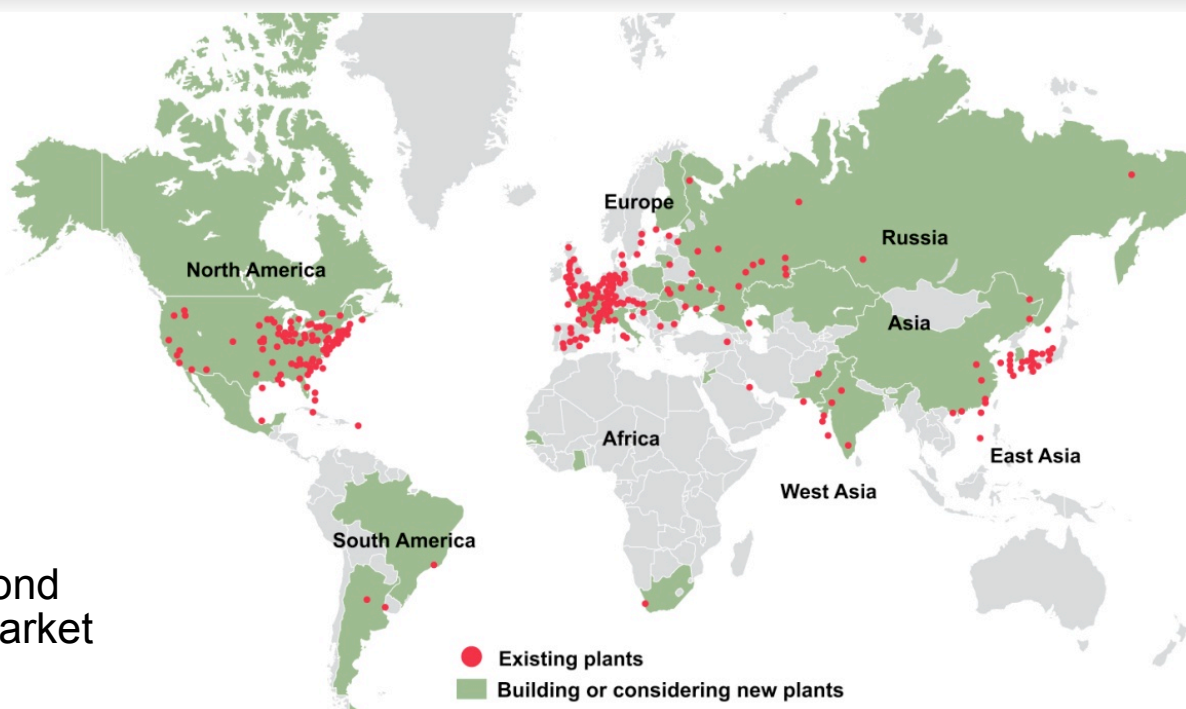


The more aggressive the CO₂ limits, the greater the importance of nuclear



Nuclear now - the world is moving forward with nuclear energy

- Nations are looking to nuclear power as energy needs rise, oil and gas prices increase, and the desire to reduce global warming increases
- Challenges
 - Extension of existing and future LWRs to increase electricity generation
 - Using nuclear energy beyond the traditional electricity market
 - Making nuclear more sustainable (addressing uranium supply and nuclear waste), while managing proliferation risks globally



439 reactors operating worldwide in 31 countries
providing 16% of electricity—93 units on order or planned

Nuclear can reduce the risk to energy security by providing an alternative to gas, oil and coal



A major obstacle for rapid growth of nuclear energy is nuclear materials management

Concerns about nuclear energy

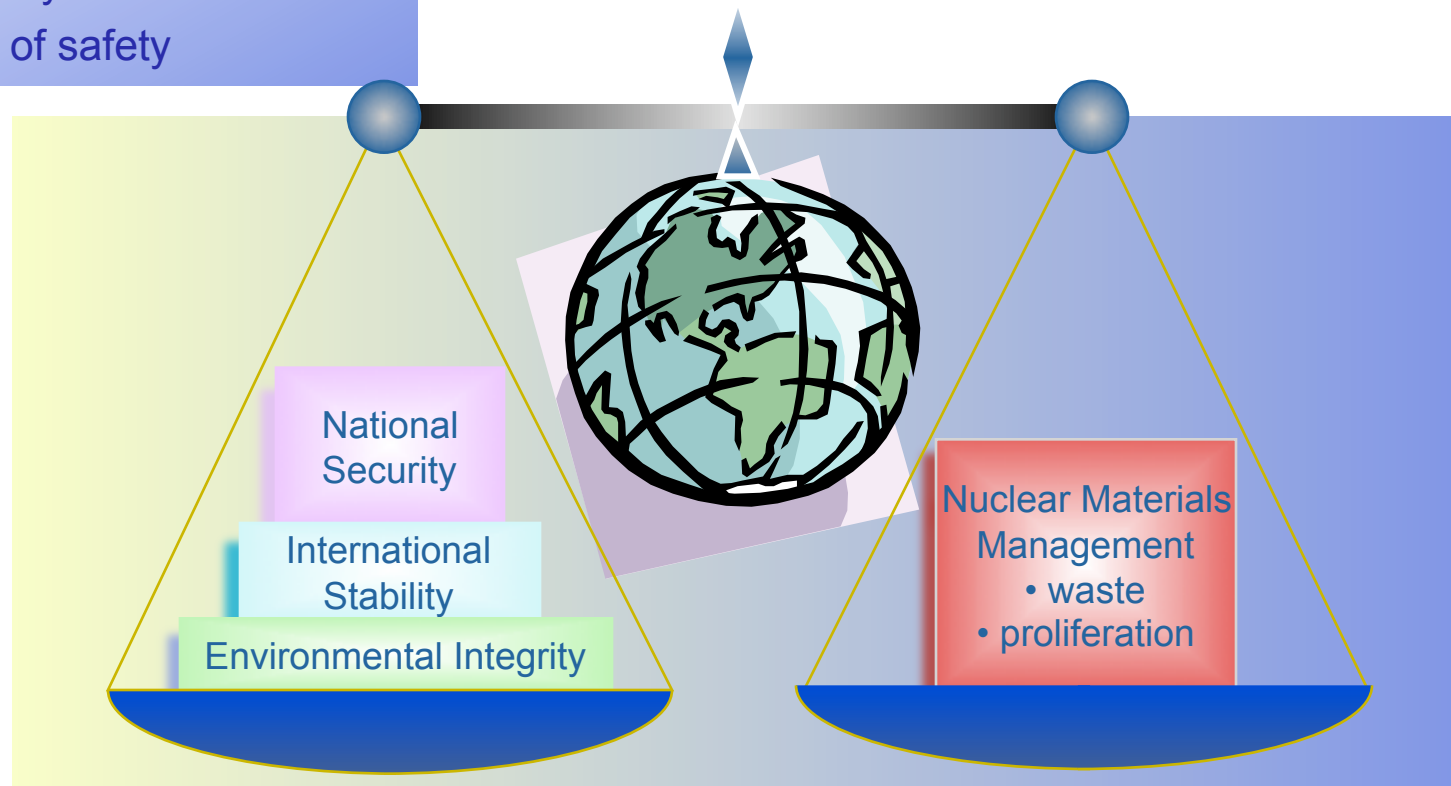
–Global nuclear materials management

- Proliferation
- Waste management

–Capital cost , R&D cost

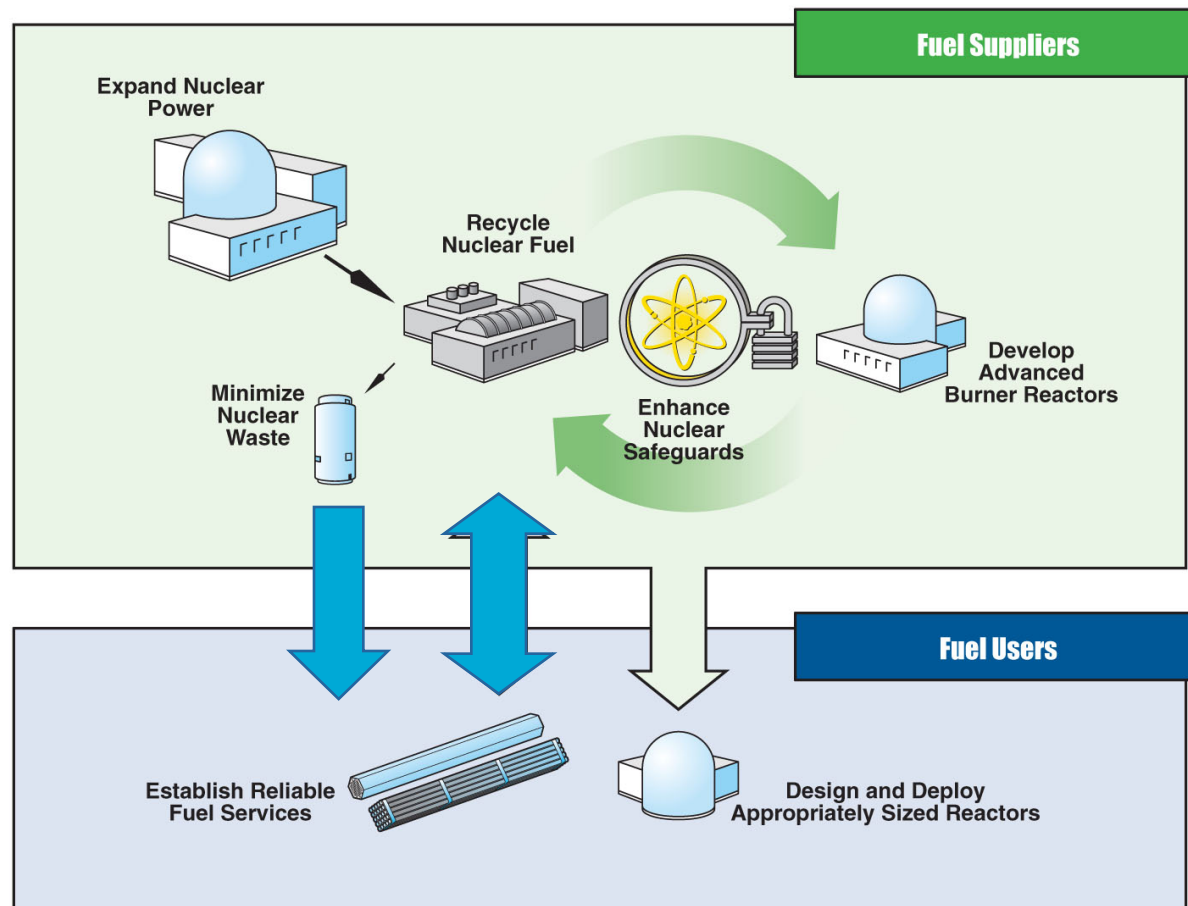
–Resource availability

–Public perception of safety





An international fuel service reduces proliferation risk



- **Fuel Suppliers:** operate reactors and fuel cycle facilities, including fast reactors to transmute the actinides from used fuel into less toxic materials
- **Fuel Users:** operate reactors, lease and return fuel.
- **IAEA:** provide safeguards and fuel assurances, backed up with a reserve of nuclear fuel for states that do not pursue enrichment and reprocessing



There is time to find a solution to the used fuel issue

- **In the US, the federal government is responsible for management of commercial used fuel**
- **Open fuel cycle and direct disposal became US policy; codified by the Nuclear Waste Policy Act**
 - Required geologic repository to open by January 1998
 - Prevented interim storage before geologic repository license issued
 - U.S. abandoned reprocessing
 - President Obama will look for solutions beyond a repository at Yucca Mountain
- **Used fuel is safe and easy to store for 50 years or more on-site**
 - Material attractiveness increases over time
 - No uranium resource issue for 50 years
 - Management of used fuel is a political and societal issue (NIMBY)

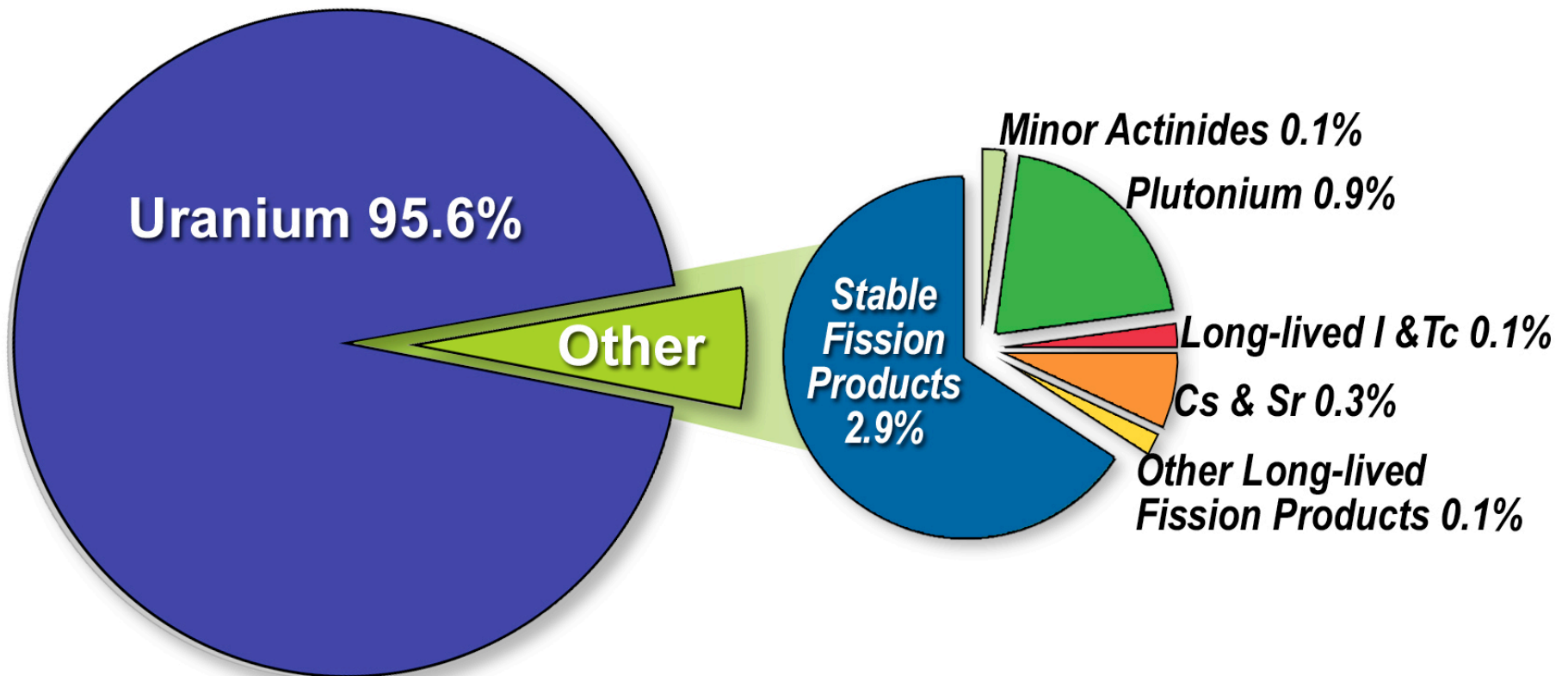


U.S. can continue to safely, securely, and cost effectively store its used fuel onsite while the licensing process continues on the repository and future fuel cycle options are explored.



Used Fuel Contains Only a Small Fraction of Long-lived Materials Toxic to Humans

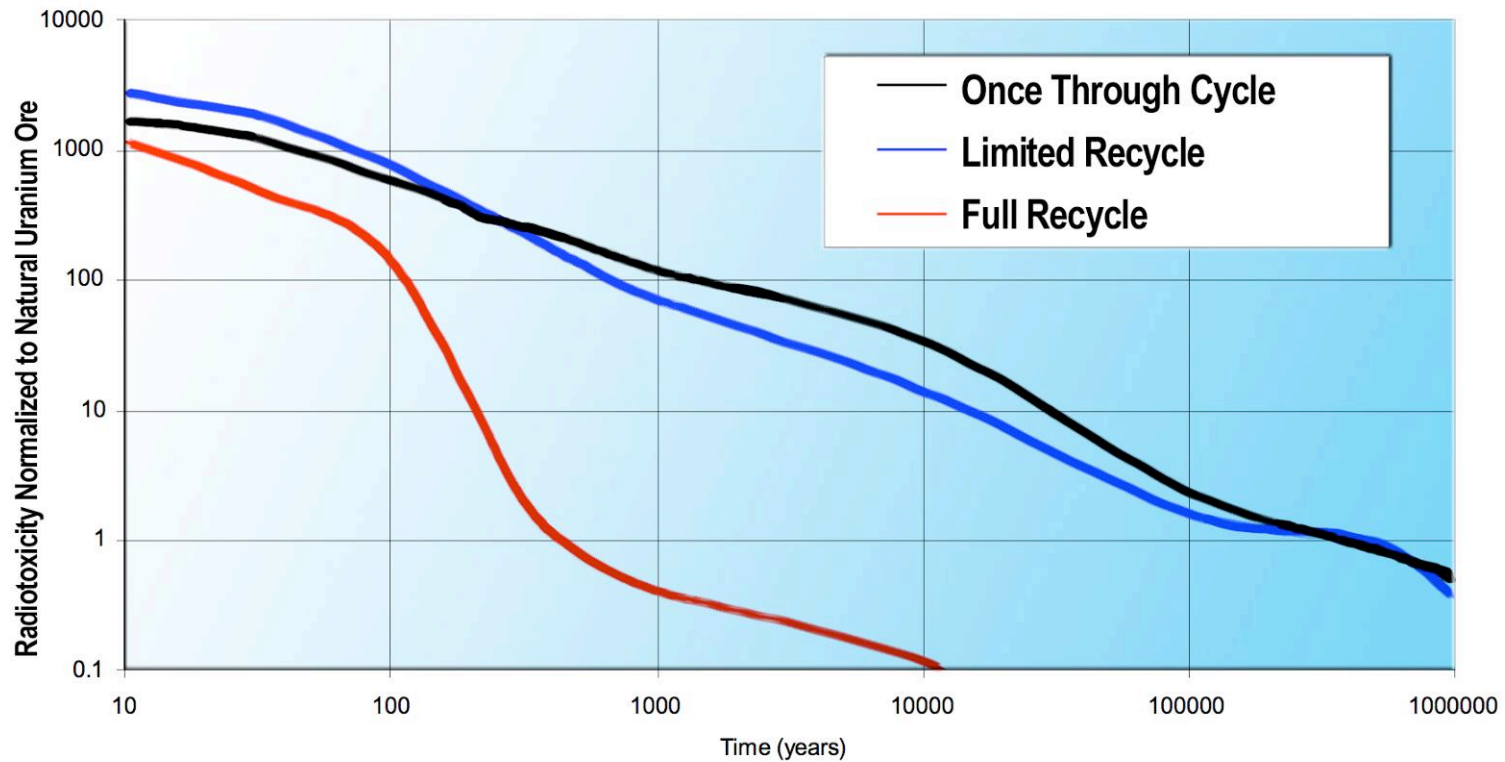
Used Light Water Reactor Fuel



How should we manage the actinides and long-lived fission products?



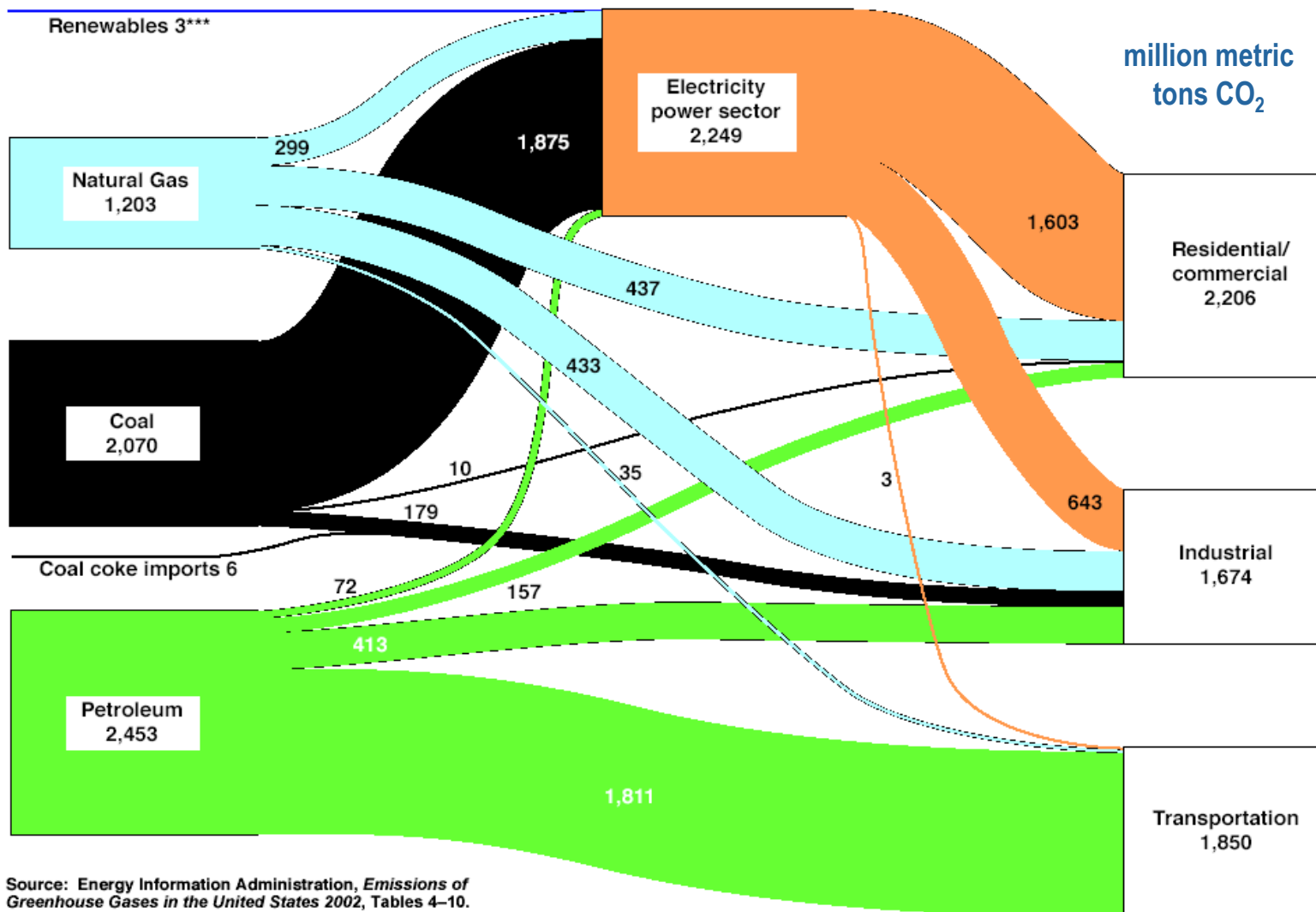
Used Fuel Presents a Million-Year Challenge in a Repository



Full recycle offers the prospect of a thousand-year solution



US CO₂ Emissions from Energy Consumption (2002)



Note: Numbers may not equal sum of components because of independent rounding.

Lawrence Livermore National Laboratory, May 2004
<http://eed.llnl.gov/flow/>



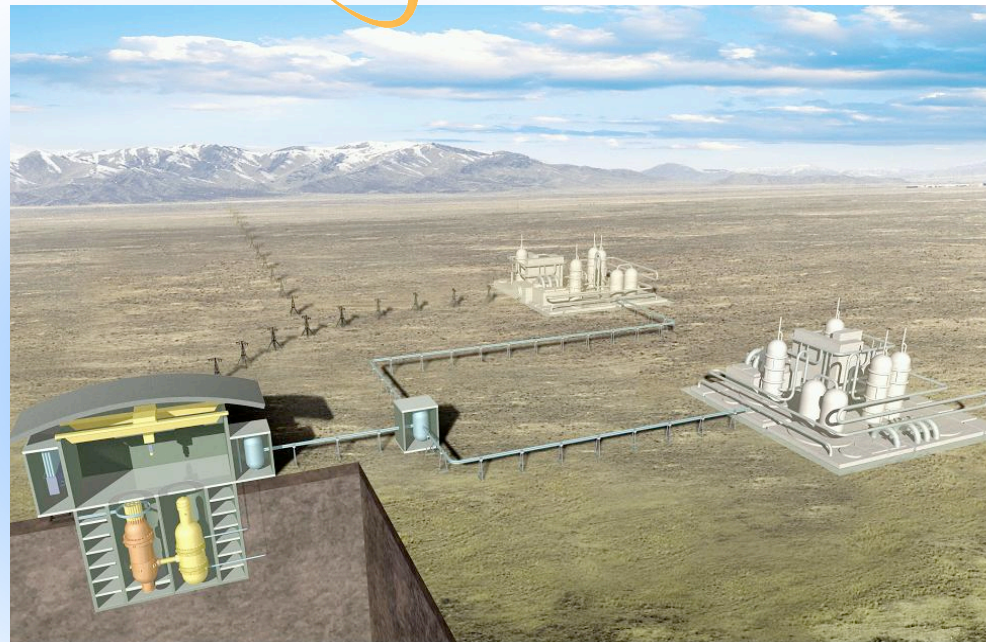
The Next Generation Nuclear Plant expands nuclear beyond traditional markets

- Provides high temperature process heat for refineries, petrochemical plants, oil recovery from oil sands, and hydrogen—about 30% of U.S. natural gas is used for this today
- Could be a key part of reducing man-made sources of CO₂ from industrial applications
- Authorized by US Energy Policy Act of 2005 – Collaboration between US DOE, nuclear system and component suppliers, and end users



Next Generation
Nuclear Plant

E=MC² The Energy of Industry



INL is Leading the Creation of an Industrial Alliance to Build NGNP



The Potential Market—Providing High Temperature Process Heat

High Temperature Gas-Cooled Reactor Energy End-Users
(Potential Number of 300-600 MW Thermal HTGRs)



Petrochemical (150)



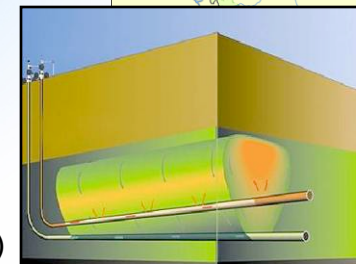
Petroleum Refining (50-100)



Fertilizers/Ammonia (100+)



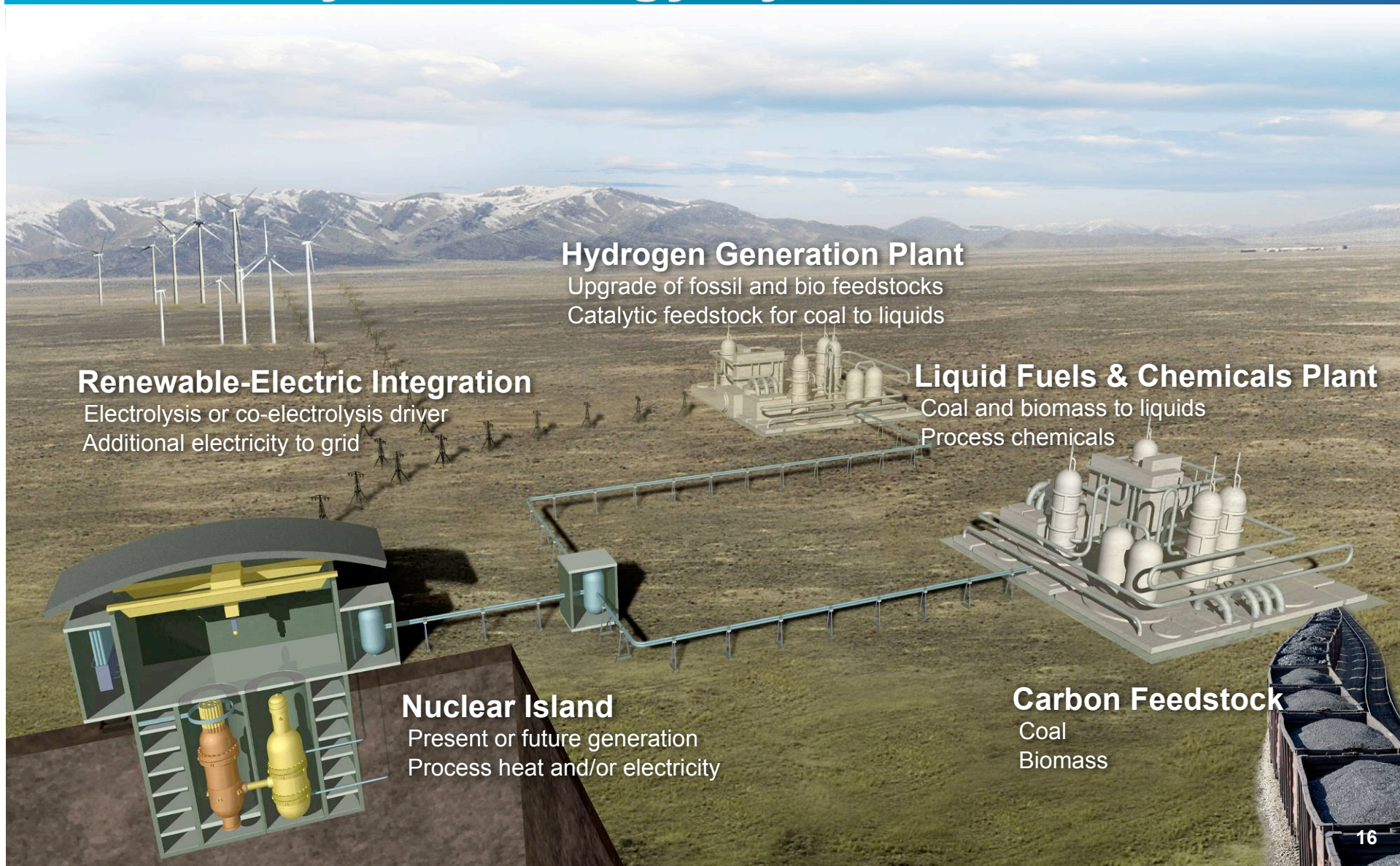
Coal-to-Liquids (100s)



Oil Sands/Shale (200+)



Re-thinking Energy for the Future — Hybrid Energy Systems



Renewable-Electric Integration

Electrolysis or co-electrolysis driver
Additional electricity to grid

Hydrogen Generation Plant

Upgrade of fossil and bio feedstocks
Catalytic feedstock for coal to liquids

Liquid Fuels & Chemicals Plant

Coal and biomass to liquids
Process chemicals

Nuclear Island

Present or future generation
Process heat and/or electricity

Carbon Feedstock

Coal
Biomass



The Future: A diverse portfolio with strong reliance on nuclear energy

- **Expanding energy options**
 - More nuclear power
 - More renewables
- **Maximizing the benefit from the current fleet of LWRs**
- **A new generation of nuclear plants**
 - ALWRs being constructed at several places in the world; ALWRs planned for the US
- **Investment in advanced R&D**
 - Next Generation Nuclear Plants
 - Fuel Cycle Technologies
- **Public support for nuclear is strong and growing stronger as the environmental benefits gain recognition**





Idaho National Laboratory